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Calibration & Temperature Controlled Setup for Air Quality Sensors

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Indoor air pollution is a major issue affecting public health. Due to hot climate, humidity and lack of natural green spaces, life is mostly confined indoors in many countries of the MENA region. Vulnerable population, including young children and senior citizens who spend most of their time indoors, are at risk because of the effects of indoor air quality (IAQ) on their health. An indoor air quality monitoring system is a need of the hour to detect and improve Indoor Air Quality (IAQ). The monitoring systems presently available are bulky, expensive and need periodic calibration to maintain high degree of accuracy. Frequent recalibration of a number of densely deployed individual sensors in the network is a time-consuming and laborious task therefore self-calibration is indispensable. Gas sensors, even if factory-calibrated, tend to drift with time/usage. Therefore these should be regularly calibrated under controlled environments. Calibration may be carried out using test gas mixtures with known composition. Pre-mixed gas cylinders with known composition may be used for the purpose; however this solution is not flexible as the number of calibration points and testing conditions (e.g. effect of temperature and humidity on CO_2 sensor) are limited. In the current project, a computer-controlled test and calibration test bed system is being designed and assembled along with temperature controller.

Calibration set-up would help in self calibration of the air quality sensors. Calibration curves obtained from proposed calibration test bed are updated automatically and fed into the sensor node through wireless communication without going in the field or replacing the sensor. A computer-controlled test and calibration test bed system is designed and assembled containing the sensor(s) under test and in which gas composition; temperature can be precisely and dynamically controlled. ATMEGA328 micro controller is used to receive the temperature set point from the computer running the test rig.

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Gas composition, temperature and humidity can be precisely and dynamically controlled in our designed test chamber containing the sensor(s) under test. Given the number of air pollutants that may be present in the atmosphere, up to 6 different gases can be mixed to calibrate the sensor nodes and investigate the issue of cross-sensitivity.

Array of 6 gas cylinders, and a gas blending system that has been designed provides continuous variation of mixture composition and temperature. Gas blending is performed using mass-flow controllers, which control a number of different gas streams, including that of an inert gas or pure air. The composition of the test gas mixture resulting from blending is controlled by varying the flow of individual gas components through the mass-flow controllers. The test chamber is fitted with heating elements and temperature sensors to control the gas mixture temperature.

The gas composition is controlled by adjusting the flow of gases in each mass flow meter; the set points for these are controlled by a computer running under MATLAB/LABVIEW environment. Each gas line is equipped with the necessary safety valves (shut down valve and one way valve). Additionally, each line has a pressure gauge to monitor the inlet gas pressure.

The temperature controller was based on an Arduino Uno microcontroller, tow (2) driver modules that incorporate a H bridge (mosfet), four (4) heaters (each 100W/24V), an LM35 temperature sensor, and two (2) fans to ensure uniform temperature inside the test chamber.

The micro controller (ATMEGA328) receives the temperature set point from the computer running the test rig; then on/off control with hysteresis is used to control temperature from room temperature to 65 °C with a precision better than 1 °C; Hence temperature is precisely and dynamically controlled so that the sensors be tested under different temperatures.

Stainless steel tubes have been used for connecting the various parts. The sealed sensor test chamber included a door that incorporated a rubber seal; all connections to the chamber included rubber seal to ensure that the inner gas composition is controlled only by the mass flow controllers.

The inner walls of the chamber are covered with heat insulation material to minimize heat transfer from the chamber and thus minimize heating power requirements. The size of the chamber was selected to allow testing of a complete wireless sensor node that includes all air quality sensors.

Sensor measurement readings are compared with a professional air quality measurement analyser named “Gray wolf IAQ Monitor” (Acquired from USA) to verify the effectiveness of the proposed system.

In future, humidification of the gas mixture will be considered using different methods, including the saturation method based on water bubble technique. The system will have a fume hood (available in our labs) for safe extraction of gases out of the calibration lab. The test bed will allow:

Calibration of procured sensors and sensor nodes.
Checking sensors cross-sensitivity and effects of environmental conditions.
Training of ANN used with the array of sensors in each node to minimize cross-sensitivity.